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# Resilience as a source of survival stategy for high-technology firms experiencing megacompetition

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**Abstract**

A dramatic surge in information technology (IT) around the world and an evolving global economy are subjecting firms to megacompetition, thereby compelling them to develop a resilient structure for survival. The construction of a co-evolutional structure between enhancement of core competences and agile correspondence to dynamically changing external circumstances, including dynamic change in customer preferences and competitive conditions, is thus essential. While technological innovation for developing new functionality is a strategic option, given the huge risks and uncertainty indigenous to technological innovation, a high level of dependence on this process can lead to a vulnerable structure. The fluctuating nature of external circumstances can also have the same result. Thus, sustainable firm development can only be expected using systems resilience incorporating a stable innovation orbit. Prompted by this postulate, this paper attempts to identify a resilience structure for high-technology firms that are experiencing megacompetition through a comparative empirical analysis of factors governing operating income to sales for R&D intensive Japanese pharmaceutical and electrical machinery firms over the last two decades.


*Keywords:* Resilient structure; Co-evolution; Megacompetition; Operating income to sales; Japan's pharmaceutical and electrical machinery firms

## 1. Introduction

Stimulated by a dramatic surge in information technology (IT) around the world and an evolving global economy, firms are now in the midst of megacompetition, which inevitably urges them to construct a co-evolutional structure between enhancement of core competences and agile correspondence to dramatically changing external circumstances.

In order to enhance core competences, convergence to certain innovation is important while divergence is essential for agile correspondence to dynamically changing external circumstances including dynamic change in customer preferences and competitive conditions. Thus, co-evolutional approach is indispensable for a simultaneous solution to these contradictory requirements (Watanabe and Nagamatsu, 2002).

An orbit control of this co-evolution requires an extremely subtle management as it sustains a simultaneous solution of contradictory issues. Under a long lasting economic stagnation in Japan while facing a megacompetition, not a few firm strays from an orbit. This is clearly observed in a contrast between two major Japanese high-technology industries, pharmaceutical and electrical machinery industries. If we compare the balance of estimated ordinary profit or loss in leading firms of these industries, we are surprised to see that while the majority of pharmaceutical firms are counted among profitable firms, many electrical machinery firms are counted among non-profitable firms.

This clear contrast in leading high-technology industries can be attributed to the different orbit of operating income to sales of these industries. While the pharmaceutical industry generally maintains its increasing trend in operating income to sales, the electrical machinery industry displays a decreasing trend after the bubble economy started from 1987.

It is generally assumed that an orbit of operating income to sales is subject to technological innovation

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and external circumstances of firms (Watanabe and Wakabayashi, 1996). However, since these factors contain uncertainty and subsequent fluctuation, a high level of dependence on them can lead to a vulnerable structure. Thus, sustainable firm development can only be expected using systems resilience[1] incorporating a stable innovation orbit.

Prompted by this postulate, this paper attempts to identity a resilience structure for high-technology firms that are experiencing megacompetition. To date, a number of studies have evaluated high-technology firms profits structure and sources supporting such profits by measuring internal rate of return to R&D investment.

Mansfield (1977) attempted pioneer work and calculated social and private returns and found that the social return (return to spillover R&D) was twice as big as the private (own) return. Bernstein and Nadiri (1991) also obtained similar conclusions. Recently Watanabe et al. (2001) computed their own and spillover return using assimilation capacity method, stimulated by Jaffe's (1986) attempt to measure technology spillover based on proximity approach. Griliches and Lichtenberg (1984) as well as Mohnen and Lepine (1988) attempted to analyze such returns by using patent flows while Terleckyj (1974) and Sveikauskas (1981) I-O flows analysis, and Bernstein and Nadiri (1988, 1989, 1991) initiated cost function approach. Mohnen (1996) attempted to identify R&D externalities and their impacts on productivity growth in OECD countries based on cost function approach. All these works correspond to the analysis aiming at identifying firms or industries profits and factors contributing to such profits.

However, these works focus on the identification of respective factors contributing to firms profits, and none have taken the perspective of systems resilience. Therefore, this paper aims at identifying a resilience structure for high-technology firms that are experiencing megacompetition by conducting a comparative empirical analysis of Japanese pharmaceutical and electrical machinery industries over the last two decades taking intensive R&D (thirty firms and twenty four firms, respectively).

Section 2 reviews states of R&D and revenue in high-technology industries. Section 3 is devoted to model synthesis. Empirical analysis and its interpretation are presented in Section 4. Section 5 briefly summarises new findings and implications for firms survival strategy in a mega-competition.

[1] The word "resilience" here means "the capability of strained body to recover from or adjust smoothly to external changes, shocks or crises".

## 2. States of Japan's high-technology industries: R&D and revenue

Triggered by a shift from heavy and chemical industrial structure in the 1960s to knowledge intensified industrial structure in the 1970s, the electrical machinery industry took a leading role in the advancement of Japan's industrial structure and made a significant contribution to its "high-technology miracle" in the 1980s. This can be demonstrated by electrical machinery's extremely big amount of R&D expenditure as 35.2% of industry total R&D expenditure in 2000 as demonstrated in Table 1.

In addition to such an extremely large amount of R&D expenditure, electrical machinery maintains a high level of R&D intensity (ratio of R&D expenditures and sales) as demonstrated in Fig. 1. Fig. 1 illustrates trends in R&D intensity at 1990 fixed prices in major sectors in Japan's manufacturing industry over the period 1979–2000.

Looking at the Fig. 1 we note that R&D intensity of electrical machinery, together with pharmaceutical which substituted for electrical machinery's highest position in 1987, demonstrates an extremely high-level and leads Japanese manufacturing industry's R&D over the whole period examined.

As demonstrated above, electrical machinery played a leading role in Japan for its economic development in the 1970s and the 1980s by shifting from heavy and chemical industrial structure to knowledge intensified industrial structure. It is the biggest sector in Japan's manufacturing industry with respect to GDP by sharing 16% of manufacturing total, and shares one third of industry's total R&D investment. However, notwith-

Table 1
R&D expenditure share in the Japan Industry in 2000 (%)[a]

| | |
|---|---|
| Agriculture | 0.1 |
| Mining | 0.2 |
| Construction | 1.7 |
| Manufacturing | 90.4 |
| ***Electrical machinery*** | ***35.2*** |
| *Chemicals* | *15.0* |
| (***Pharmaceutical***)[a] | **( *6.9* )** |
| *Transport machinery* | *14.3* |
| *General machinery* | *8.1* |
| *Precision instruments* | *4.5* |
| *Food* | *2.1* |
| *Other manufacturing* | *1.5* |
| Transport, telecommunication, public utility | 5.6 |
| Software industry | 1.9 |
| Industry total | 100.0 |

Source: Report on the Survey of Research and Development (Statistics Bureau, Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT), 2001).

[a] Pharmaceutical is encompassed in chemicals.